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ART. I.—*Observations upon the Kidney and its Excretions in different Animals.* By JOS. JONES, Student of Medicine in the University of Pennsylvania. (With 20 wood-cuts.)

THE object of this paper is to present a general view of the kidney and its excretions, and to direct attention to certain facts and principles which have been much overlooked. For the thorough investigation of this subject many years of hard labour will be required; since not only must correct quantitative analyses of the urine be made, but also of the blood of different animals. Our knowledge of the blood and of the secretions and excretions of animals, with the exception of those of the mammalia, is as yet very limited and indefinite; indeed, we know nothing whatever about the chemical and physical properties of the blood and urine of the cold-blooded animals.

I. *Comparative Anatomy of the Kidney in Vertebrate Animals.*

1. MAMMALIA.—The urinary apparatus in mammalia consists, with a few exceptions, of four distinct portions:—

1. The glands which separate the urine from the blood.
2. A duct which conveys this excretion to a reservoir.
3. A receptacle for the urine.
4. A canal leading from the reservoir to the exterior of the body, through which the urine is discharged out of the animal economy.

These parts exist in all mammalia except the monotremata, in which the fourth division of the apparatus is absent, and the ureters empty into the cloaca. The separation in these animals of the uro-urethral from the semino-urethral passages demonstrates conclusively that the existence of the penis is essentially and subordinately related to the sexual organs, and not to the renal.

The kidneys are situated, in all cases, in contact with the posterior walls of the abdominal cavity, on either side of the vertebral column and aorta, resting partly upon the psoas magnus muscle. The right kidney, owing to the position of the liver, is generally situated lower than the left. The exterior border of the kidney is convex, and looks outwards towards the parietes of the abdomen. The interior border looks towards the vertebral column, and is concave, being excavated by a deep fissure, in which enter the nerves, arteries, veins, and excretory ducts. When a section is made, it is found to consist of two distinct portions—an external, vascular (cortical), and an internal or tubular (medullary) substance.

The substance of the kidney is divided into pyramidal masses, having their bases towards the surface, whilst their apices extend into the pelvis or the branches of the ureter. The number of these pyramids varies in different animals. In many of the quadrumana, cheiroptera, insectivora, and rodentia, there is only a single pyramid, whilst in the seals there are one hundred, and in the dolphins two hundred. These characters are possessed in general by the kidneys of all vertebrata.

The exterior form of the organ differs in the various orders. In man, its shape is oval, resembling a kidney-bean, whence its name. An external form similar to this is found in the kidneys of the apes, cheiroptera, and many of the rodentia and ruminantia. In most carnivora they are much rounded. In the mink they are much elongated.

In several animals which have only a single pyramid of Malpighi, the apex is prolonged, gradually coming to a point, thus forming a vermiform appendage, which projects through the pelvis of the kidney into the ureter. This structure may be seen in the kidneys of the red bat (*Nycticeus Noveboracensis*), common mole (*Scalops Aquaticus*), and the house mouse (*Mus Musculus*).

In many cats and weasels, the kidneys are, upon their external surface, incompletely lobed, resembling those of new-born infants. Many animals, especially those inhabiting the water, have these organs divided externally into many distinct lobes. Of this form, the kidney of the common cow presents the most familiar example. This is elongated, and has from eighteen to twenty-four distinctly-marked lobes; each of these is in reality a separate kidney, having a cortical and medullary substance, forming a pyramid of Malpighi, the apex of which is surrounded by a branch of the ureter.

The enlarged dilated superior portion of the ureter, called the pelvis, does not exist in the cow; the ureter continues of a uniform size during the whole course, from its junction with the bladder to the point where it sends off branches to the different lobes. This peculiar lobulation of the kidney is well marked in other animals. In the otter there are twelve, and in the bear from forty to fifty lobes. The seals have this organ divided into from seventy to one hundred lobes; in consequence of this minute division, its surface presents a tessellated appearance. The kidneys of the true cetacea have a racemose appearance, and in those of the dolphin there usually exist two hundred lobes. The

external characters of the kidneys of these last-mentioned animals resemble those of some birds, as the turkey-buzzard (*Cathartes Aura*), and of all the reptiles, and several fishes, as the catfish (*Galeichthys Marinus*), the toadfish (*Batrachus Tau*), and the stingray (*Trygon Sabina*).

Above each kidney is situated a small body, called the supra-renal capsule, the office of which is as yet unknown. The form of this varies with different animals: thus, it is of the shape of a cocked hat in man, and the general shape of the kidney in the mole; and lobulated in the cetacea and other aquatic mammalia. This would seem to indicate that some relation exists between these two organs. In what that relation consists, we are at present unable to say, because we are ignorant of the office which the supra-renal capsules perform in the animal economy.

a. *Minute Anatomical Structure of the Kidney in Mammalia.*—The minute anatomical structure of these organs, in all the mammalia thus far examined, resembles in every respect that of the human kidney. We have examined carefully, under the microscope, the kidneys of various animals, as the cow, raccoon, rabbit, squirrel, and others, both injected and uninjected, and in every case the structure was the same. The tubuli uriniferi were seen, consisting of a basement membrane, lined with epithelial cells, and ending in club-shaped extremities and dilatations, which embraced the convoluted mass of a vein and artery, thus forming the corpuscles of Malpighi.

The microscopical anatomy of the kidney of man is described in every recent work on anatomy, and it is therefore unnecessary to do so here.

b. *Development of the Tubuli Uriniferi.*—The kidneys of a small fœtus of the common mouse, when examined under the microscope, were seen to consist, in large measure, of innumerable, elongated, and spheroidal cells. Amongst these, only a few short portions of the tubuli uriniferi were seen, and appeared to have been formed by the coalescence of these elongated cells. The kidneys of a fœtus of the same animal, in a more advanced state of development, was also examined. The ureter was distinctly seen entering for a short distance the substance of the kidney, connected with which were many short tubuli uriniferi. The ends of these short tubes were, in many instances, connected with chains of elongated cells, which had coalesced together. Some of the urinary tubes terminated in closed, rounded extremities, resembling the free extremities of cells which had not as yet united with others. The substance of the kidneys was composed, in great measure, of spheroidal and elongated cells, amidst which short portions of the urinary tubes were seen, having continuations and branches formed by the union of these elongated cells. These facts indicate that the urinary tubes are formed from spheroidal cells, which, elongating in opposite directions, coalesce, and the walls, where they come in contact, are removed by absorption.

c. *Relative Size of the Kidneys in the different Orders of Mammalia.*—Although our investigations of this subject are by no means complete, still,

we hope that the following facts and conclusions will interest and excite careful observers to investigate this subject for themselves. The relation existing between the weight of the kidneys and the weight of the body of an animal was obtained by accurately ascertaining the weight of the animal, and then of its kidneys, and dividing the former by the latter. The average weight of the bodies of several raccoons was found to be eighty times heavier than the average weight of their kidneys.

Compare this result, obtained from carnivorous animals, with the relative weights of the kidneys and bodies of animals which subsist entirely upon vegetable food. The rabbit was found to weigh one hundred and fifty-eight, and the gray squirrel one hundred and ninety times as much as their kidneys. The kidneys of the raccoon, a carnivorous animal, are relatively twice as large as those of the rabbit and squirrel, herbivorous animals.

If the character of the food, the structure and size of the digestive apparatus, and the habits of the two classes of animals be attentively considered, we will understand at once why this relative difference in size should exist in organs fulfilling the same office in both. The food of the carnivora, as the name implies, consists of flesh and blood, which is capable of ready digestion and absorption, and rapidly supplies the wants of the animal economy. The intestinal canal is in all cases short, when compared with that of the herbivora, and in some individuals is not much longer than the body.

Carnivorous animals have voracious, and, in some cases, almost insatiable appetites. They gorge themselves with food, which is capable of entering the circulation with little or no alteration, and rapidly supplying the wants of the economy. There must be some organ to act as a safety-valve, and remove rapidly the large, unnecessary quantities of nutriment which are so often received into the circulatory system. To accomplish this effectually, there must be correspondingly large organs.

In the herbivora, on the other hand, the intestinal canal is very long; in the case of the sheep, it is twenty-eight times the length of its body. In this class of animals, the food consists of vegetables, which require minute subdivision, and the principles which they contain must go through many metamorphoses before they are ready to supply the wastes and wants of the system. Consequently their introduction into the circulation is gradual, the elimination of the products of the disintegrations of the tissues, whose place they supply, must be correspondingly slow and gradual, and a much smaller-sized organ will perform the same office in them than in the carnivora.

2. *AVES*.—The kidneys of birds are impacted within deep cavities of the sacrum, and extend from the lungs to within a short distance of the anus. They retain the impressions of the last ribs, and the transverse processes of the sacrum. They are, in all cases, lobulated; each kidney having from three to five principal lobes. In several orders, their general form is determined

secondarily by that of the sacrum, and primarily by the habits of the birds. Thus, in cranes having a long slender body, they frequently come in contact in the median line, and even coalesce, as in the *Ardea Candidissima*.

In the chimney-swallow (*Chætura Pelagica*) and in the woodpeckers, where the sacrum is broad, for the attachment of the strong muscles of the tail and legs, the kidneys are correspondingly broad and short.

In birds of prey, as the fish-hawk (*Pandion Haliaetus*), which have a broad, deep sacrum for the support of the powerful muscles of the lower extremities, the kidneys are thick, broad, short, and deeply impacted within the cavities of the sacral bone. As far as our observations have extended, we may say that, as a general rule, the more powerful the exertions of a bird, the more active and energetic its habits of life, the more carefully will its kidneys be stowed away in the cavities of the sacrum. The necessity for this provision is evident when we consider the delicate nature of these organs, and the serious disturbance of the animal economy which immediately follows the infliction upon them of direct or indirect injuries. In the three other classes of vertebrate animals, the great Architect has placed them in contact with the posterior walls of the abdominal cavity, a position least of all liable to injury. In mammalia, reptiles, and fishes, the kidneys are protected by the vertebral column, and large and powerful dorsal muscles. In birds, these muscles are absent, because they are unnecessary in their peculiar structure and modes of locomotion. What better arrangement for the protection of these organs could have been devised, than that they should have been covered with bone at the part where they are most exposed? The peculiar form of the sacrum in birds, appears then to have been intended for the reception and protection of the renal organs.

Fig. 1 represents the kidneys of the small white crane (*Ardea Candidissima*), reduced to one-fourth its natural size, showing their union and coalescence in the median line. Fig. 2 represents the kidneys of the wood ibis (*Tantalus Loculator*), also reduced to one-fourth its natural size. The kidney of this bird presented, exteriorly, numberless small lobules, which are represented in the shaded portion of the drawing. These figures will give a better idea of the shape and positions of the renal organs, testicles, and supra-renal capsules, than a long and elaborate description.

The supra-renal capsules are small, flat, orange-colored bodies, always found on the mesial line of the anterior extremities of the kidneys. They are in contact externally with the large vascular trunks, and are generally covered by the testicles in the male, and the ovaries in the female. These organs are represented in Fig. 2 (*b*), and are seen lying above the testicles (*c*), which were remarkably small in this bird, in other respects an unusually large and fine specimen. In Fig. 1, we see that the supra-renal capsules are completely covered by the testicles (*a*, *a*).

The kidneys of struthious birds have small pyramids of Malpighi surrounded by calyces, and in the ostrich is found a true renal pelvis.

The ureters descend along the anterior surface of the kidneys, and terminate by perforating the cloaca posteriorly and superiorly. A true urinary

Fig. 1.



Fig. 2.

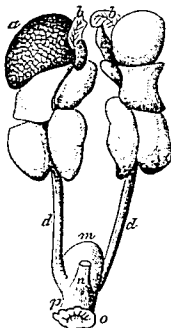


Fig. 1. Kidneys and testicles of the small white crane (*Ardea Candidissima*), one-fourth the natural size. *a, a*, Testicles. The supra-renal capsules lie between these and the anterior surface of the kidneys. *b*, Right kidney. *c*, Left kidney. These coalesce at their inferior portion. *d, d*, Spermatic cords. *n, m*, Ureters.

Fig. 2. Kidneys of the wood ibis (*Tantalus Loculator*), one-fourth the natural size. *a*, Superior lobe of right kidney, upon the surface of which are represented the small lobuli. *b, c*, Supra-renal capsules. *c*, Testicle. *d, d*, Ureters. *m*, Bladder-like expansion of the cloaca, considered by many anatomists a rudimentary bladder. *n*, Inferior portion of the rectum. *o*, Anus. *p*, Cloaca.

bladder is absent, although in many birds the ureters open into a distinct pouch-like dilatation of the cloaca. This may be seen in Fig. 2 (*m*). It is bounded above and below by a valvular fold, which separates it from the urethro-sexual cavity and the rectum (*n*).

a. Minute Anatomical Structure.—The kidneys of birds are composed of minute lobuli, which, in some individuals, as the *Tantalus Loculator*, can be distinguished externally. (Fig. 2, *a*.) In the turkey-buzzard (*Cathartes Aura*) they are convoluted, giving to the surface a tessellated aspect. In other birds, they are polyhedral. These lobules are connected with separate branches of the ureter, and have the shape of the pyramids of Malpighi. Towards their apices, they consist of converging tubuli uriniferi forming the medullary portion, whilst the cortical or outer parts consist of the branches and convolutions of these urinary tubes. These tubuli uriniferi, in all the birds whose kidneys we have examined under the microscope, end, as in mammalia in the Malpighian bodies, in loops, or in simple club-shaped extremities.

The absence of a pelvis and calices in the kidneys of most birds, appears to be absolutely necessary, when we consider the character of their urine,

which is semi-solid, consisting of innumerable small globules of the urate of ammonia. If there were any cavities in which this could accumulate, renal calculi would be of frequent occurrence. The existence of cilia in the cells lining the interior of the urinary tubes, has not as yet been accurately determined. Gerlach thinks that he has seen them on one occasion in the fowl. Although they were not noticed by us in our microscopical examinations of the kidneys of the *Pandion Haliaetus*, *Ardea Discors*, and other birds, still, we think that it is highly probable that they do exist, because they would aid materially in the movement and expulsion of these minute globules of the urate of ammonia.

b. *Relative Size of the Kidneys of Birds.*—So far as our observations have extended, the same law holds good with birds as with mammalia. The kidneys are relatively larger in the carnivorous than in the frugivorous or granivorous birds. A glance at the following weights will render this evident:—

Weight of <i>Ardea Candidissima</i> , 86 times the weight of its kidneys.				
"	"	<i>Discors</i> ,	100	" " " "
"	"	<i>Garrulus Cristatus</i> ,	115	" " " "
"	"	<i>Picus Auratus</i> ,	121	" " " "

The first two birds are carnivorous, feeding upon fish and crustacea, whilst the last two live upon a mixed diet of berries and insects. In the carnivorous birds, the intestinal canal is much shorter than in those living upon a vegetable or mixed diet. Their food is capable of more rapid digestion and introduction into the circulation, and, as a necessary consequence, the organ which regulates the amount of the solid and fluid materials of the blood, and eliminates all waste and useless matters, must be correspondingly larger.

According to our investigations, the average weight of the kidneys of birds is relatively greater than that of mammalia. That this should be the case, might be expected from the constitution of birds. Their circulation is more rapid than that of the mammalia; the temperature of their bodies is some ten degrees higher, and their mode of life is, in all respects, more active and energetic. They consume relatively more food, and the skin is not so active in its functions. The necessary consequence of all these actions is, that the materials of their bodies will more rapidly undergo change, and need a corresponding rapid supply of nutriment, and organs adequate to perform the offices of secretion and excretion.

The weight of the turkey-buzzard is not more than seventy times the weight of its kidneys. Here we have a bird which lives exclusively upon animal food, which gorges itself on all occasions with an unnecessary amount of food: the consequence is that it must have large organs, capable of eliminating from the blood a large amount of useless materials.

3. *REPTILIA.*—The kidneys of reptiles are situated, like those of mammalia and fish, in contact with the posterior walls of the abdominal cavity, and lie upon each side of the vertebral column. In this class they are always lobu-

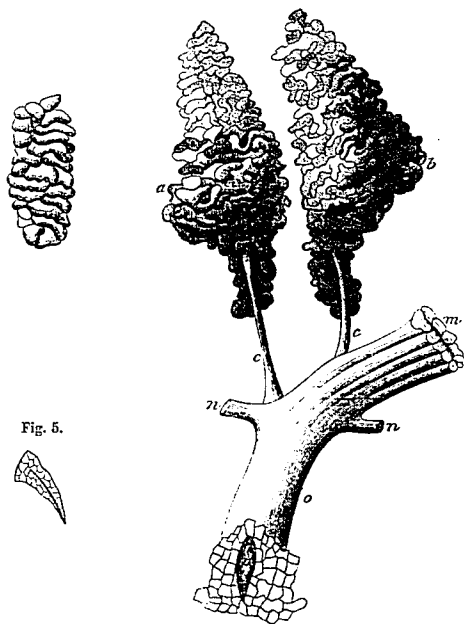
lated, but differ widely as to length, breadth, and general form, and position in the different orders.

In the chelonian and batrachia, their general form may be described as elongato-oval. Fig. 3 represents the kidney of the *emys terrapin*, natural size.

In the sauria they are triangular, broad, and thin, with numerous convoluted lobules. Fig. 4 represents accurately the kidneys of the *Alligator Mississippiensis*, reduced to one-ninth the natural size. Fig. 5 is the kidney of the six-striped lizard (*Ameiva Sexlineata*).

Fig. 3.

Fig. 4.

Fig. 3. Kidney of the *emys terrapin*, natural size.Fig. 4. Kidneys of the *Alligator Mississippiensis*, one-ninth the natural size. Length of alligator six feet. a. Right kidney. b. Left kidney. c, c. Ureters. m. Rectum. n, n. Oviducts. o. Cloaca. p. Anus.Fig. 5. Kidney of the six-striped lizard (*Ameiva Sexlineata*), natural size.

In the ichthyodea and tailed batrachia they are narrow, and run to a point anteriorly.

In the ophidia they are narrow and much elongated, and often situated asymmetrically. In this order, the effect of the general form of the animal upon that of its kidneys, and in fact upon all the internal organs, is very perceptible. In the coachwhip snake (*Psammodphis Flagelliformis*), a long, slender serpent, constructed for swift motion, the kidneys are correspondingly long and slender, and are situated asymmetrically, the one above the other, the abdominal cavity not being sufficiently capacious for both, lying parallel. This form and arrangement of the kidneys may be said to be due, primarily, to the habits and mode of life of this snake. It subsists upon lizards and insects, which are active and swift. Their enemy must be correspondingly constructed for activity and swiftness of motion. The same observations apply to the black-snake (*Crotalus Constrictor*) and other reptiles having the same habits.

The rattlesnakes, bull-snake (*Pituophis Melanoleucus*), and others, which live by force and stratagem, rather than by activity, have a large stout body, and correspondingly broad and thick kidneys. Fig. 6 represents the kidneys of the coachwhip snake (*Psammodphis Flagelliformis*) reduced to one-fourth their natural size.

In the ophidia and sauria, a urinary bladder is absent, the ureters open directly into the cloaca, as may be seen in Figs. 4 and 6.

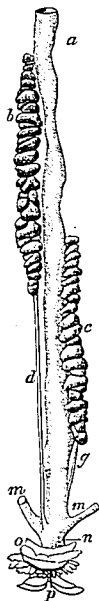
The chelonia have a large bladder, and the ureters, instead of penetrating its walls, empty themselves directly into the cloaca in front of it, so that the urine has to reascend to the urinary reservoir.

The ureters in ophidia are situated upon the internal inferior edges of the kidneys.

The supra-renal capsules are found in the sauria, chelonia, and ophidia, and are generally of a yellow colour, and elongated, lobulated form, and situated above the kidneys, either within the folds of the peritoneum, or more freely near to the sexual organs.

a. *Minute Anatomical Structure.*—The essential structure of the kidneys is nearly the same throughout all the orders of reptiles. The distinction between the cortical and medullary substance does not exist in this class.

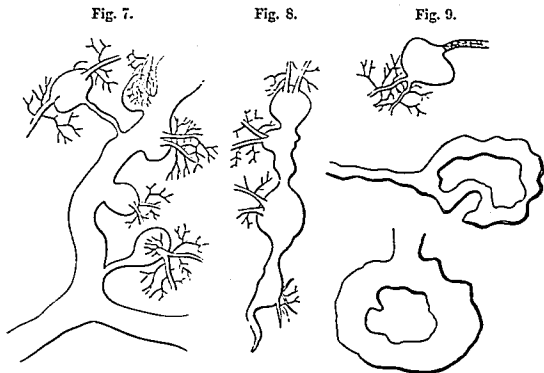
Fig. 6.



Kidneys of the coachwhip snake (*Psammodphis Flagelliformis*), one-fourth the natural size. a. Large intestine. b. Right kidney. c. Left kidney. d. Right ureter. e. Left ureter. m, m. Inferior portions of the ducts of the ovaries. n. Cloaca. p. Anus.

The ureter, which runs along the entire length of the organ, sends off numerous canals, which are short in the lower orders, and long and convoluted in the higher. These urinary tubes form groups constituting lobules, which receive branches from the portal trunk that supplies the organ with blood. In the animals of this class, whose kidneys we have examined under the microscope, we have invariably found the tubuli uriniferi terminating in club-shaped extremities, loops, and Malpighian corpuscles.

Figs. 7, 8, and 9, represent a magnified view of the tubuli uriniferi of



Tubuli uriniferi, and corpuscles of Malpighi, from the kidney of the glossy black pine-snake (*Pituophis Melanoleucus*). Magnified about 100 diameters.

the glossy black pine-snake (*Pituophis Melanoleucus*), which were injected with the chromate of lead. It will be seen, from this injection, that the dilata-tions of the urinary tubes occur all along their course, the Malpighian cor-puscles being not restricted, as in mammalia, to the cortical substance, but distributed throughout the entire substance of the kidney. The ciliary motion has been discovered, by Bowman and other observers, in the neck of the Malpighian bodies, and in the commencement of the tubuli uriniferi of ser-pents, and also of the frog, salamander, triton, bombinator, and bufo. The ciliary motion is in the direction of the urine, towards the ureter. The utility of this arrangement is evident, when we consider that in many of these ani-mals, as the ophidia, the urine is in a semi-solid condition, containing nume-rous globules of the urate of ammonia.

b. Relative Size of the Kidneys of Reptiles.—The kidneys of the sauria and ophidia are larger than those of the chelonians and batrachia. The

former are carnivorous, and much more voracious than the latter. The kidneys of the ophidia are relatively much larger than those of either mammalia or birds. The body of the pine-snake (*Pituophis Melanoleucus*) was found to be not more than sixty times as heavy as its kidneys. The kidneys of carnivorous birds and mammalia are not relatively so heavy.

The question immediately arises, why should cold-blooded animals, whose circulation is sluggish, who eat but seldom, often abstaining from food for months, and even years, and whose habits are indolent, be provided with large urinary organs? In birds, we have seen that an elevated temperature, rapid circulation, and active, energetic mode of life, called for large organs, capable of removing in an efficient manner from the blood the products of the disintegrations of the system; and here we have a condition of things, directly contrary in every respect, calling for still larger organs to perform the same office.

In attempting to explain this phenomenon, we must consider the following facts and laws of the animal economy. The blood contains a definite amount of materials to be eliminated by the kidneys, diffused through its entire mass. That all these materials should be separated, the entire mass of the blood must be presented to these organs; and the rapidity of the elimination will depend upon the rapidity of the circulation, the activity of the excreting cells, and the size of the organs.

The temperature exerts a great influence upon all the actions of the animal economy. It is a well-known fact that seeds will not germinate or eggs hatch; or, in other words, life action will not commence or continue below a certain temperature. If the temperature of the cold or warm-blooded animals be reduced much below the normal standard, their functions will gradually become more feeble, and finally cease altogether. It may be stated, as a general law, that the lower the temperature of any organ, the more feeble will be its action. Nervous force exerts a great influence upon secretion. It is known to every naturalist that cold-blooded animals have much less muscular and nervous power, in proportion to their size, than the warm-blooded animals.

From these considerations, then, it is evident that to perform the same office, to secrete precisely the same amount, larger organs are required in the cold than in the warm-blooded animals.

The character of the alimentary canal, and the habits of serpents, also render the existence of large kidneys necessary. These animals are carnivorous, and have a short alimentary canal, which, in many instances, is almost completely straight. They take their food in large quantities, often swallowing animals heavier and larger than themselves. All this animal matter is capable of digestion and absorption into the blood, a large portion of which is superfluous. The great channel for the elimination of this is the kidneys; the lungs being mere sacks, and performing the function of respiration in an imperfect manner.

4. PISCES.—In the different orders of this class, we find many diversities in the general form and situation of the kidneys. There is no special type, and the development of the kidney does not, by any means, correspond with the position which the fish occupies in the classification of naturalists. The kidneys of fish of a low order, as the stingray, resemble, in position, structure, and appearance, those of the chelonians and batrachia, and appear, in more respects than one, to be of a higher organization than the kidneys of many of the acanthopterygii and other fish occupying relatively much higher ranks. We will give a few examples, to show the general position, character, and diversities of the kidneys of different fish.

The kidneys of the garfish (*Lepisosteus Osseus*) commence immediately beneath the heart and opening in the œsophagus (through which air passes into the lung), on each side of the inferior portion of the cranium, and extend throughout the length of the abdominal cavity to within about one-fourth of an inch of the anus. Their posterior surface is in contact with the vertebral column and the posterior walls of the abdominal cavity, while their anterior surface lies in contact with the posterior surface of the lung. They are covered with dense fibrous tissue, which is reflected from the lung over the kidneys, and unites with the fascia of the posterior walls of the abdominal cavity.

The vertebrae upon their anterior face have a prominent central keel, which is perforated. Through this perforation pass portions of the kidneys on each side, and coalesce together. In this respect, the kidneys of this remarkable fish, the connecting link between reptiles and fish, differ from all others that we have yet examined. The kidneys fill up the depressions in the vertebra, and those in the posterior walls of the abdominal cavity between the ribs; they are therefore lobulated.

Their length is very great, whilst their breadth is comparatively small, as will be seen in the following measurements:—

Length of fish	2½ feet.
Length of each kidney	12 inches.
Breadth “ “	⅓ths of an inch.

A section of the kidney, showing its position, appearance, and the perforation of the keel, is shown in Fig. 10.

The ureters run along the edges of the kidneys next to the vertebral column. They dilate into a bladder, which is situated posteriorly to the rectum.

The lung extends from an opening in the œsophagus, throughout the length of the abdominal cavity. It is capable of great distension, having, when inflated, a diameter almost equal to that of the fish.

The salt-water catfish (*Galeichthys Marinus*), belonging to the same order as the garfish, malacopterygii abdominales, has both kidneys coalesced into one; thus differing entirely in appearance, relative dimensions, and position,

from those of the garfish. The general shape of the body of the kidney may be said to be semi-lunar. Superiorly it is wide, and gradually tapers until it

Fig. 10.

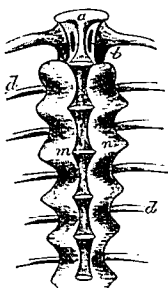


Fig. 11.

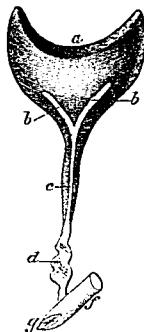


Fig. 10. Section of the kidneys of the garfish (*Lepisosteus Osseus*). Natural size. a. Articulating surface of the vertebra. b. Aperture in the anterior central prominent portion or keel of the vertebra, through which the kidneys pass and coalesce with each other. c. Anterior surface of the vertebral keel. d, d. Ribs. m. Right kidney. n. Left kidney.

Fig. 11. Kidneys of the salt-water catfish (*Galeichthys Marinus*). Natural size. Length of fish 10 inches. a. Superior concave border of the kidneys, which receives the inferior convex border of the air-bladder. b, b. Right and left branches of the ureter. c. Ureter. d. Bladder. f. Rectum. g. Anus.

reaches the bladder. The superior border is concave, and embraces the posterior convex border of the air-bladder. Fig. 11 will give a much more accurate idea of its appearance than any description.

In many of the acanthopterygii, as the whiting (*Umbrina Alburnus*), the yellowtail (*Leiostomus Xanthurus*), the young drum (*Pogonias Fasciatus*), the croaker (*Micropogon Undulatus*), the sheephead (*Sargus Ovis*), and the angel-fish (*Ephippippus Faber*), the general position and arrangement of the kidneys are similar, in most respects, to those of the garfish. The toadfish (*Batrachus Tau*), placed by naturalists in this order, has kidneys differing in position, size, appearance, and, in fact, in every respect from these individuals. They are short, thick, elongato-oval, resembling, in every respect, the same organs in the plagiostomi, fish of a much lower organization, according to the classification of naturalists, and also those of many reptiles, as the chelonina, sauria, and batrachia.

The kidneys of the stingray (*Trygon Sabina*), resemble, in structure, appearance, and situation, those of the chelonina and batrachia, and, among fishes, those of the toadfish. Fig. 12 represents the kidney of the stingray. By comparing this with the kidney of the emys terrapin (Fig. 3), or those of the alligator (Fig. 4), the resemblance will immediately be seen.

Fig. 13 represents the kidneys of the whiting (*Umrina Alburnus*), reduced one-third their natural size.

Fig. 12.



Fig. 13.

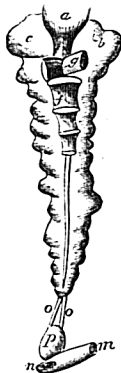
Fig. 12. Kidney of the stingray (*Trygon Sabina*).

Fig. 13. Kidneys of the whiting (*Umrina Alburnus*). One-third the natural size. Length of fish 12 inches. a, Inferior portion of the cranium. b, Left kidney. c, Right kidney. g, Muscular attachment of the esophagus to the vertebral column. f, Vertebra. o, a, Ureters. p, Bladder lying posterior to the rectum. m, Rectum. n, Anus.

This may be taken as the type of the kidneys of nearly all the fish belonging to the order Acanthopterygii. By comparing with each other Figs. 10, 11, 12, and 13, we will see at once that there is no definite type of kidneys for each order, or for fish as a class. A bladder is present in many individuals of this class, and in all cases it lies posterior to the rectum, differing in this respect from the arrangement of the bladder in mammalia and reptilia, and resembling in its position the rudimentary bladder of birds. This one fact will serve to distinguish fish from all other animals.

The supra-renal capsules are very small in fishes. In some orders, they are small, bean-shaped bodies, of a pale colour, connected by vessels with the apex of the kidneys. In others, they are small, reddish-white corpuscles, placed behind the kidneys, against the vertebral column.

a. *Minute Anatomical Structure*.—The kidneys of fish consist of tufts of urinary tubes, which are sent off transversely at intervals from the long ureter, and are connected together by the loose fibrous tissue which supports the network of vessels distributed upon their walls. When portions of the kidney of the garfish (*Lepisosteus Osseus*) were carefully viewed under the microscope, numerous tubuli uriniferi were seen, dividing and subdividing into dis-

tinuous branches, in some cases terminating in loops, in others, in club-shaped dilatations, and in others still, in cup-like dilatations, which embraced convoluted masses of bloodvessels. These corpuscles of Malpighi, although small, were distinct and well formed. The urinary tubes in most fish are long and tortuous, but seldom ramified. The corpora Malpighiana are generally present; they are, however, in some of the lower orders, as the cyclostomi, imperfectly formed. The minute anatomical structure of the kidneys of fish reminds us of that of the corpora Wolfiana, the temporary renal organs of the higher vertebrata.

b. Comparative Size of the Kidneys of Fish.—Owing to the great difficulty of separating thoroughly and accurately, the kidneys from the vertebral column, to which, in most individuals, they closely adhere, this subject has not been investigated far enough to allow of general conclusions.

The following weights are not without some interest:—

Weight of catfish,	90	times heavier than that of its kidneys.
“ “ toadfish, 114	“	“ “ “ “ “
“ “ stingray, 177	“	“ “ “ “ “

II. Comparative Anatomy of the Kidney in the Invertebrate Animals.

In this class, the kidneys, like all the other organs, are much more simple in their structure than those of the vertebrata. The following are the most important results of the recent researches of Siebold and other anatomists.

1. *ARTHROPODA.*—In the class insecta, the kidneys consist of small tubes, varying in length, number, and modes of grouping in the different orders. These tubes open upon the posterior or pyloric extremity of the stomach, by means of one or two common excretory ducts. These ducts are sometimes dilated, bladder-like, at their point of insertion. The free extremities of the uriniferous tubes generally terminate cœcally or anastomose with each other. When very long, they form numerous convolutions around the digestive canal, and sometimes creep with their anterior extremities between the coats of the stomach, or by their posterior between those of the colon. They are composed of a homogeneous external tunic or basement membrane, filled internally with large cells, disposed in rows, so that nowhere can there be perceived in the interior of the vessel a glandular canal defined by a special epithelium. Each cell contains a colourless nucleus, and a multitude of very fine yellow or brown granules. These cells are ruptured, and the granular bodies, which constitute the urinary secretion, pass through the spaces between the cells, and flow gradually into the intestinal canal. The urinary organs of the larvæ and pupæ of this class resemble somewhat those of the perfect insect.

The urinary organs of the arachnoidæ consist of small, usually multiramous glandular tubes, which open into the cloaca, and exactly resemble the Malpighian vessels of the insecta, both by their structure and the nature of the fluid which they secrete.

In the crustacea, up to the present time, urinary organs have been observed only in the myriapoda, and like those of the insecta, they consist of very small, brownish, coecal vessels, describing many convolutions around the stomach and intestines, and open into the digestive canal at the boundary between the stomach and intestine.

2. MOLLUSCA.—The urinary organs of the cephalopoda present the appearance, externally, of variously ramified glandular tufts, connected with the venæ cavæ, and sometimes with the principal veins. Careful examinations have shown these organs to consist of an internal parenchyma, composed of a contractile fibrous tissue, through which are spread branches coming from the venæ cavæ. This parenchyma is surrounded by a structureless membrane, covered with several layers of nucleated granular cells. The urine, of a dirty yellow colour, is secreted from the external surface of this cellular layer, and escapes immediately into the peritoneal cavities, and then is discharged externally through their orifice. The peritoneal cavities in this function resemble urethral canals.

With most of the cephalophora, the kidney consists of an uneven lamellate gland, which is usually situated near the bronchial or principal pulmonary vein. The excretory duct accompanies the rectum, and often opens near the anus. The gland is surrounded by a sac-like envelop, which is continuous with the internally ciliated excretory duct. Upon the exterior of this membranous envelop, which appears to act the part of a basement membrane, ramify bloodvessels. In the gland itself, no bloodvessels have been observed. Each renal lamella is composed of thickly-set, delicate cells, loosely bound together, containing a transparent liquid, in which float brown or violet-coloured nuclei. These nuclei are in form round and embossed; they have a dense crystalline structure, and are undoubtedly a product of renal secretion, because they contain uric acid.

A very remarkable organ, found in all the lamellibranchia, known as the gland of Bojanus, has been demonstrated to be undoubtedly of a renal nature. This organ is always double, and consists of a large, long sack, with glandular walls of a dirty yellow or dark green colour. It is situated on each side of the back, between the pericardium and the inferior abductor muscle, and extends usually upon the sides of the abdomen to the base of the branchiæ. These glands communicate with the cavity of the mantle, by two small openings, which have swollen borders, and are situated sometimes at the upper and sometimes at the lower end of the sac. The usually very thin walls of these two sacs have numerous folds or plicæ, which form compartments or areolæ, all of which are covered with a very delicate ciliated epithelium. The parenchyma of these walls is composed of a very loose tissue, which, upon the least disturbance, separates into small granular cells. Many of these cells contain a blue-black, round nucleus, which is very solid, and sometimes so large as to be visible to the naked eye as an inorganic concretion.

As these nuclei contain uric acid, they may be compared to renal calculi. The walls of these kidneys are surrounded by a distinct network, which arises from the large venous reservoir in which the afferent blood of the body is accumulated.

No special organs for the excretion of the urine have as yet been discovered in the vermes, zoophyta, or protozoa.

III. *The Excretions of the Kidney in the Vertebrata and Invertebrata.*

The offices of the kidney in the animal economy are—

1. To separate from the blood those products of the breaking-down and metamorphosis of the tissues which can be of no further use in the animal economy, and which, if retained, would be productive of evil consequences.
2. To remove an excess of nutritive materials, when they have been introduced into the blood in an amount beyond what is necessary to supply the wants of the animal economy.
3. To draw off from the blood any extra, unnecessary amount of water.

The active agents in these processes, in all animals, both vertebrate and invertebrate, are the epithelial cells lining the basement membrane of the tubuli uriniferi, or the renal sacs. These cells possess a power of separating certain materials, as urea and uric acid, from the blood, whilst they allow its other constituents to pass untouched. That this power of depurating the blood is resident in them alone, is conclusively demonstrated by the fact that, when they are removed from the basement membrane of the tubuli uriniferi, immediately albumen and other constituents of the blood, not normally excreted by the kidneys, appear in the urine. The basement membrane of the urinary tubes, then, does not possess this power of selection. The power which these cells possess, of preventing certain materials of the blood from passing through them, is definite, and capable of being overcome by pressure. When the walls of the heart are preternaturally thickened, so that the blood is propelled with great force through the circulatory apparatus, it often happens that the power of selection in the cells is overcome, and albumen and other necessary constituents of the blood are forced out along with the excrementitious matters, and appear in the urine.

The distinction between an excretion and a secretion should here be drawn. These acts have been confounded by almost every physiologist.

The circulatory apparatus not only carries nutriment to the different organs and tissues, but also removes from them the products of their disintegration and metamorphoses, which can be of no further use in the animal economy. The act of separating these materials from the blood is called excretion. The process is one of simple separation. The amount and character of an excretion depend entirely upon the amount and character of the excrementitious materials existing in the blood.

If the kidneys be extirpated, their office will be assumed by the skin, and even the gastro-mucous membrane. In like manner, if the function of the skin be checked, it will be assumed by the kidneys. The act, then, of separating certain materials from the blood can be transferred from one excretory organ to another.

A secretion does not pre-exist in the blood. We do not find the gastric juice or the salivary fluid existing in the blood before they are elaborated by special organs. Each secretion must have a special set of cells, which alone can produce the peculiar material. We never find one organ elaborating the secretion of another distinct organ. This is a fixed law. The salivary gland never secretes gastric juice, nor the mamillary gland bile. The stomach of a rattlesnake never secretes the deadly fluid of its poison-gland. Thus, in two essential respects, an excretion differs from a secretion.

In both excretion and secretion, the active agents are organic cells. Under the microscope, these cells present very much the same appearance; there are no distinctive characters corresponding to their different offices. The most accurate means of investigation which we possess have failed as yet to give us any satisfactory interpretation of a great phenomenon, which lies at the foundation of all our knowledge of living beings. How do organic cells elaborate particular products, or separate certain materials from the blood? Medicine can never, in truth, be considered a science until this question is definitely settled.

A series of experiments, which I performed last summer, throws a faint glimmering of light upon this subject. Animal membranes were filled with solutions of certain chemical substances, as oxalate of ammonia, and immersed in solutions of other substances, as chloride of calcium, which would form uncrystallized, insoluble precipitates when mingled. It was found, when endosmose and exosmose of the solutions had taken place, that the precipitates were crystalline, and differed in the physical arrangement of their particles on the opposite sides of the membranes. The physical influence exerted by the membranes differed with the direction of the current. By extending the experiments, it was found that membranes from different parts of the same animal, or from relatively the same parts in different animals, effected different physical arrangements of the molecules of the same body. When live frogs were allowed to remain for a certain length of time in a solution of the oxalate of ammonia, and carefully washed and transferred for a similar length of time to a solution of the chloride of calcium, beautiful octohedral, dumb-bell, cubical, and ellipsoidal crystals of the oxalate of lime were found, by the aid of the microscope, in the blood and different tissues. Similar results were obtained when the cut ends of growing plants were treated in a similar manner. These experiments were repeated, with similar results, with various other chemical substances.¹ Here, then, we have animal and vegetable

¹ For further details of these experiments, the reader is referred to the department of "American Intelligence" in this number.—Ed.

membranes and cell-walls, both living and dead, altering the physical arrangement of the molecules of inorganic compounds. In the dead animal membranes, all vital influence was absent. This change was brought about entirely by their physical constitution. That it was not due to the presence of blood, or putrefying organic matters, or some other fluid, was proved by numerous experiments, carefully performed.

It is remarkable that the physical forms impressed both by the living and dead animal membranes upon the oxalate of lime, were precisely those which occur in the urine of various animals, and even in that of birds and fishes. Is the conversion of albumen into albuminose more wonderful, or does it require more power than this influence exerted by a dead animal membrane upon an inorganic substance? Do not the results of these experiments render it probable that many secretions and excretions in the animal economy are the results of purely physical causes? It is highly probable that membranes, by minutely dividing and separating the ultimate particles of substances passing through them, communicate to them certain motions, thus changing their molecular arrangement, and with it their physical and chemical properties.

In considering the causes which influence the physical and chemical properties, and relative amounts of the excretions of the kidney in different animals, we should investigate carefully the following subjects:—

1. The Amount, Force, and Rapidity of the Circulation of the Blood. When definite substances in limited proportions are required to be eliminated from the blood by any organ, the activity of that organ will depend upon the activity of its excreting cells; the amount of blood supplied to those cells, and the force with which it presses against them. The influence of arterial pressure upon the function of the kidneys is conclusively proved by M. Bernard's experiments. A dog having an arterial pressure of 76 millimetres, its kidneys secreted 0.80 grammes of urine in a minute. When the pressure of the blood was increased to 112, by tying all the arteries of the limbs, 12.23 grammes were secreted in the same length of time. Another animal, in whom the pressure was reduced by bleeding to 57, passed in one minute 2.06 grammes. The pressure was raised to 122 by the injection of blood into the circulation, and then 19.34 grammes of urine passed. These experiments were varied and performed in several instances, and always with the same result; the quantity of urine increased or diminished with the increase or diminution of the force of the circulation.

2. The Activity of the Glands of the Tegumentary System, which are connected with, and materially modify the function of the kidneys. They both secrete from the blood, substances closely allied in physical and chemical constitution. The quantity of these substances is limited. The sluggishness, or increased activity of the one, therefore, must necessarily produce a state directly opposite, in the other.

3. The Action of the Colon. In some animals, the colon performs an im-

portant office in the depuration of the blood, whilst in others, as reptiles, its function in this process is exceedingly feeble.

4. The Activity of Respiration. An intimate connection exists between the function of the lungs and the materials eliminated by the kidneys. Upon the function of respiration depends, in a great measure, the production of heat, and upon the temperature depend many of the chemical changes taking place in the animal economy.

5. The Physical and Vital Constitution, and Modes of Living, influence materially the size and activity of the kidneys, and the amount and character of its excretions. Birds, whose circulation is rapid, whose temperature is high, whose exercise is frequent, swift, and violent, need large kidneys, to eliminate in a corresponding manner the incessant wastes of their tissues. Serpents who seldom take food, but who, when they do, gorge themselves with large and unnecessary quantities, need an organ which will be able to eliminate this superabundant mass of nutritious matter, which has been received by absorption into the blood. In cold-blooded animals, the temperature is low, the circulation sluggish, respiration imperfect, and, as a necessary consequence, all the operations of secretion and excretion are correspondingly slow, and require relatively much larger organs to accomplish the same amount of labor than those of the more highly organized.

1. *Urine of the Vertebrata.*

1. *Urine of the Mammalia.*—As the character of the urine is affected greatly by the nature of the food, animals may be divided into three great classes: Carnivora, Herbivora, and Omnivora. The urine of the first two, will have specific characters, whilst that of the latter will resemble both, or partake of the characters of one or the other exclusively, according to circumstances.

a. *Urine of the Carnivora.*—The urine of this class of animals, as a general rule, is of a much higher specific gravity, and more scant in quantity than that of the herbivora, for several important reasons. Their nutriment is of a much more concentrated form, and does not contain so large an amount of fluids. Their mode of life is more energetic and active, necessarily leading to a greater wear and tear of the tissues. And also the glands of their tegumentary system are not so numerous or active. Hieronymus examined the urine of lions, tigers, and leopards, and found it to be alike in all.

At a temperature of 50° F. to 55° F., the specific gravity of the urine from the same animal varied from 1059 to 1076.

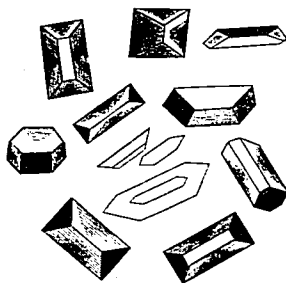
The mixed urine of these three animals gave the following result:—

Water	846.00
Solid constituents	154.00
Urea, alcohol-extract, and free lactic acid	132.20
Uric acid	0.22
Vesical mucus	5.10

men of urine from another red bat, innumerable beautiful prismatic crystals of the triple phosphate were deposited a short time after it was taken from the bladder.

These are represented in Fig. 15. When treated with a drop of concentrated nitric acid, the whole mass of urine immediately became solid, pre-

Fig. 15.



Crystals of triple phosphate, deposited in great number in the urine of the red bat, when slightly evaporated. Magnified 210 diameters.

sending to the naked eye a white silvery, opaque, crystalline appearance. Under the microscope, it was seen to consist of a conglomerated mass of lozenge-shaped crystals of the nitrate of urea. The following are the principal constituents of the urine of the *Nysticeus Noveboracensis* :—

Urea, in great abundance.
Uric acid.
Chloride of sodium.
Phosphate of lime.
Phosphate of ammonia.

Urate of ammonia.
Purpurine.
Phosphate of soda.
Phosphate of magnesia.

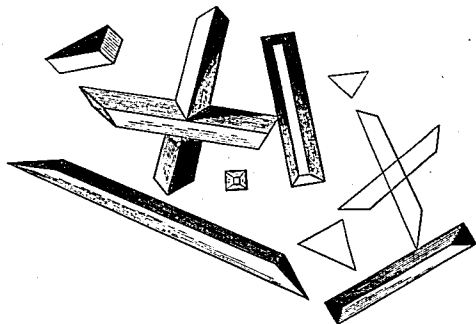
The fact that the urine of the bat contains so large an amount of urea may be due in some measure to its high temperature and rapid circulation. According to the observations of Tiedemann and Rudolphi, the temperature of the bat varies from 106° to 105° F. According to another observer, its heart beats 200 times in a minute. This rapid circulation must be attended by a correspondingly rapid disintegration of the fluids and tissues.

It is to be regretted that specimens of the urine of wild carnivorous animals can rarely be obtained. This is the case with not only the small, but also the large animals. From the bladders of ten raccoons and one mink, I was unable to obtain a single drop of urine for microscopical or chemical examination.

b. *Urine of Herbivora*.—In the urine of animals of this class, uric acid is replaced by hippuric acid. The amount of the solid constituents, in proportion to that of the water is much less, and the specific gravity, as a necessary consequence, much lower than in the urine of carnivorous animals.

Qualitative Analysis of the Urine of the Gray Squirrel (*Sciurus Carolinensis*).—Owing to the small capacity of the bladder of this animal, it is impossible to obtain a sufficient quantity of urine for a quantitative analysis. The urine is of an amber colour. When allowed to stand for a short time after its removal from the bladder, beautiful prismatic crystals of the triple phosphate were deposited, and were visible to the naked eye as a silvery-white precipitate. Fig. 16 represents a deposit of very long and delicate crystals of this salt.

Fig. 16.



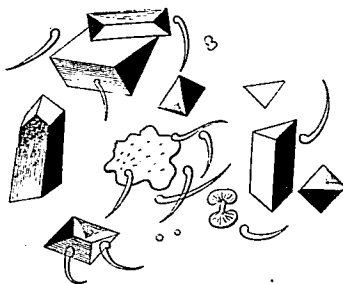
Prismatic crystals of triple phosphate, precipitated from the urine of the gray squirrel (*Sciurus Carolinensis*), which was placed upon a glass slide, and allowed to remain for one hour. Magnified 210 diameters.

Under the microscope, these differed somewhat in form in different individuals. In several instances, two of the prisms, as represented in the figure, were united so as to form a cross.

Fig. 17 represents the same deposit which took place in the urine of several squirrels collected in a test-tube. It was rutting season, and the spermatozoa are distinctly seen, many of them adhering to the crystals. A well-formed dumb-bell crystal, of the oxalate of lime, is also seen. The precipitation of these crystals results from the formation of ammonia, one of the products of the disintegration of the nitrogenized constituents of the urine. The ammonia thus formed neutralizes the small amount of free acid in the urine, which renders the triple phosphate soluble. When the urine was treated with aqua ammonia, stellate crystals of this salt made their appearance in great numbers.

The presence of urea was determined by slightly evaporating a portion of the urine, and treating it with a drop of concentrated nitric acid; this was

Fig. 17.



Prismatic crystals of triple phosphate, spermatozoa, and a dumb-bell crystal of the oxalate of lime, deposited from the urine of several gray squirrels, which was placed in a test-tube and allowed to remain for two hours. Magnified 210 diameters.

followed by the production of numberless lozenge-shaped crystals of the nitrate of urea. The quantity of urea present appeared to be greater than that which normally exists in the urine of man, and smaller than that of the red bat. When the urine was treated with nitric acid and evaporated over the spirit lamp, and then treated with ammonia, but a slight change to the purplish-red colour took place, denoting the presence of uric acid in very small amount. This acid, however, exists in a larger proportion in the urine of some squirrels. In one instance, where the urine was spread upon a glass slide and slowly evaporated, crystals of uric acid made their appearance in moderate abundance.

The presence of hippuric acid was rendered evident, by slightly evaporating the urine and treating it with acetic or hydrochloric acids. Under the microscope, it presented the form of delicate acicular crystals. When the urine, thus treated with hydrochloric acid, was still further evaporated, chloride of sodium crystallized in cubes and crosslets. In the urine of one individual, which was spread upon a glass slide and allowed slowly to evaporate, hippuric acid made its appearance in considerable abundance. The following are the principal constituents of its urine:—

Urea.

Uric acid, in small amount.

Hippuric acid.

Soda, probably combined with hippuric and uric acids.

Oxalate of lime.

Phosphate of lime.

Phosphate of ammonia.

Phosphate of magnesia.

Qualitative Analysis of the Urine of the Wood Rat (*Neotoma Floridana*).—This animal lived about a corn-house and stable. When the urine was simply spread upon a glass slide and allowed slowly to evaporate, prismatic crystals of triple phosphate, numerous acicular and arborescent crystals of hippuric acid, and cubes and crosslets of chloride of sodium, successively made their appearance under the microscope. When treated with nitric acid, heat, and ammonia, no trace of uric acid was discovered. Urea appeared to be present only in small quantities. The addition of aqua ammonia precipitated stellate crystals of triple phosphate. The following are its principal constituents:—

Urea, in small amount.	Chloride of sodium.
Hippuric acid.	Phosphate of magnesia.
Phosphate of lime.	Phosphate of ammonia.

Qualitative Analysis of the Urine of the Common Rabbit (*Lepus Sylvaticus*), slightly alkaline in its reaction. Specific gravity 1020.—When first deposited, the urine presented a turbid, milky appearance. After standing for a time, a white, chalk-like precipitate settled to the bottom. Under the microscope, this deposit, in some instances, consists of minute globules often conglomerated together, resembling, in all respects, the urate of ammonia; in other cases, it consists of large globules. That this deposit does not contain urate of ammonia, or any uric acid whatever, is proved by the fact that it gives no purplish-scarlet colour when treated with nitric acid, heat, and aqua ammonia.

When mixed with the hydrated oxide of potassium, no ammonia was evolved; and, when heated in water, it was not dissolved. When treated with nitric, hydrochloric, or acetic acids, effervescence takes place, and the deposit dissolves, and, under the microscope, numerous acicular crystals of hippuric acid make their appearance. By close microscopical and chemical investigation, this deposit was found to contain the hippurate of soda. In the deposits, which consisted of large globules, were found dumb-bell crystals of the oxalate of lime.

The following are the principal constituents of the urine of the *Lepus Sylvaticus*:—

Urea.	Oxalate of lime.
Hippurate of soda.	Phosphate of lime.
Carbonate of soda.	Phosphate of magnesia.
Carbonate of lime.	Phosphate of ammonia.

Quantitative Analysis of the Urine of the Hare.—The urine of this animal has been examined on two occasions by Von Bibra, who collected three pints from seven or eight hares, by external pressure on the region of the bladder. The first analysis was made in December. Hippuric acid was found to be present in small quantity, forming 0.007 $\frac{2}{10}$ of the urine.

The ash contained :—

Chloride of sodium, with a little chloride of potassium	7.12
Sulphate of soda	16.82
Carbonate of soda	9.84
Phosphate of soda	53.05
Phosphates of lime and magnesia	13.17
	100.00

The following is the analysis of the urine obtained in a similar manner in the month of June. Faint alkaline reaction. In the course of six hours, crystals of ammoniaco-magnesian phosphate were observed upon the surface. Specific gravity 1050; 1,000 parts contained :—

Water	912.86
Solid constituents	87.14
Urea	8.54
Hippuric acid	microscopic crystals.
Alcohol-extract	9.58
Water-extract	32.68
Soluble salts	23.70
Insoluble salts	12.64

The ash consisted of—

Chloride of sodium, with a little chloride of potassium	22.49
Sulphate of soda	29.97
Carbonate of soda	8.73
Phosphate of soda	4.39
Phosphate of lime	12.00
Phosphate of magnesia	22.42
	100.00

The urine of Guinea-pigs resembles in many respects that of the hare, and herbivorous animals generally.

The urine of beavers, according to the qualitative analysis of Vauquelin, contains carbonate of lime and magnesia, urea, hippurate of soda, and other ordinary ingredients of the urine of herbivorous animals, but no phosphates or uric acid. He also detected in the urine the undecomposed colouring matter of the willow, one of the constituents of the ordinary food of the beaver.

The urine of elephants has been examined by Vogel, who found it turbid from carbonates of lime and magnesia floating through it. According to his analysis, it contained no trace of hippurate of potassa, but, on the other hand, urea is more abundant than in that of the rhinoceros. Brandes, who afterwards examined the urine of elephants, found hippuric acid, combined both with an alkali and urea.

The urine of the rhinoceros was also examined by Vogel. He found it turbid and yellow, resembling clay-water mixed with ochre, having a peculiar smell, not unlike that of mashed ants. When exposed to the air, it becomes

darker, and is covered by a pellicle of small crystals of carbonate of lime. It effervesces with acids, and becomes clear. When allowed to stand, it deposits a yellow powder, amounting to 2½ per cent. of the urine, and consists of the carbonates of lime and magnesia, combined with a nitrogenized animal matter mixed with sesquioxide of iron and silica. The addition of hydrochloric acid to the urine, previously evaporated to one-third of its volume and filtered, precipitates hippuric acid to the amount of 0.45 per cent., which was previously combined with potassa. The urine of this animal also contained urea and the ordinary salts.

The urine of the pig has been analyzed by Van Setten, Von Bibra, Bous-singault, and Lassaigüe. Considerable and important discrepancies exist between the different analyses, which may be due to various causes, as difference of food, relative amounts of fluids consumed by the animals, time of the year, &c. The following is the analysis of Van Setten. Urine, colour yellow, inodorous; specific gravity 1003; 1,000 parts contained—

Water	990.028
Solid constituents	9.972
Urea	0.750
Uric acid	0.195
Water-extract	1.708
Alcohol-extract	1.105
Resinous matter	0.425
Albumen and mucus	0.721
Lactic acid	0.490
Stearin	0.092
Sugar	0.375
Phosphate of soda	1.376
Sulphate of potash, chlorides of sodium and potassium	2.075
Sulphates of lime and magnesia	0.425
Sulphate of ammonia	0.196
Chloride of ammonium	0.010

The following is an analysis of the urine of a pig feeding upon potatoes and water, slightly impregnated with salt, by Boussingault. Urine alkaline, limpid, and of a pale-yellow colour; specific gravity 1013.6; 1,000 parts contained—

Water and indeterminate organic matter	979.14
Urea	4.90
Bicarbonate of potash	10.74
Carbonate of magnesia	0.87
Carbonate of lime	traces.
Sulphate of potash	1.98
Phosphate of potash	1.02
Chloride of sodium	1.28
Alkaline lactates	undetermined.
Hippuric acid	absent.
Silica	0.07

In all the analyses of the urine of the pig, that have thus far been published, hippuric acid is absent. It is a little remarkable that this acid should not be present in the urine of animals living entirely upon a vegetable diet.

The urine of the horse has been analyzed by Fourcroy, Vauquelin, Chevreul, Simon, Boussingault, and Von Bibra. It is of a straw-colour, not unfrequently turbid; at first acid, but soon becomes ammoniacal, and then emits a peculiar, penetrating odour. It deposits, on standing, a mixture of carbonate of lime and magnesia. The specific gravity varies, with different individuals, from 1030 to 1050, according to their life, whether one of labour or quietude, and also with the relative amounts of fluids and solids consumed. The mean specific gravity of the urine of horses used for agricultural purposes may be stated to be about 1045.

The following analyses of Von Bibra and Boussingault are the most recent and perhaps the most correct.

In two analyses of the urine of the same horse, made at different periods, Von Bibra found—

	(1)	(2)
Water	885.09	912.84
Solid constituents	114.91	87.16
Urea	12.44	8.36
Hippuric acid	12.60	1.23
Water-extract	21.32	19.25
Alcohol-extract	25.50	18.26
Mucus	0.05	0.06
Salts, soluble in water	23.40	40.00
Salts, insoluble in water	18.80	

The individual salts in one hundred parts of saline residue, determined upon two occasions, were—

	(1)	(2)
Carbonate of lime	12.50	31.00
Carbonate of magnesia	9.46	13.07
Carbonate of potash	46.09	40.33
Carbonate of soda	10.33	
Sulphate of potash	13.04	9.02
Chloride of sodium	6.94	5.60
Silica	0.55	0.98
Loss	1.09	

Traces of iron were observed, but he was unable to determine the presence of fluorine. The deposit which falls after the urine has stood for some time was found in three analyses to consist of—

	(1)	(2)	(3)
Carbonate of lime	80.9	87.2	87.5
Carbonate of magnesia	12.1	7.5	8.2
Organic matter	7.0	5.3	4.3
	100.0	100.0	100.0

The horses were used for agricultural purposes, and fed on hay and oats.

Von Bibra states that the prevailing opinion that, by excessive work, the hippuric acid is replaced by benzoic acid, is incorrect. Benzoic acid was generally absent; and, when present, could only be recognized by the aid of the microscope.

The following is an analysis, by Boussingault, of the urine of a horse fed on trefoil and vetches. Specific gravity 1037.3; reaction alkaline; 1,000 parts contained—

Water and indeterminate matters	910.76
Urea	31.00
Hippurate of potash	4.74
Lactate of potash	11.28
Lactate of soda	8.81
Bicarbonate of potash	15.50
Carbonate of lime	10.82
Carbonate of magnesia	4.16
Sulphate of potash	1.18
Chloride of sodium	0.74
Silica	1.01
Phosphates	absent.

Boussingault, although he distilled upwards of twenty-six gallons at a single experiment, was unable to obtain a trace of the red oil which several chemists have noticed as a constituent of the urine of the herbivora, and on which the colour and odour are said to depend.

The urine of horned cattle was first examined by Rouelle, who stated that it contains urea in larger quantity than that of man, and also hippurate of soda. Exposed to the air, it deposits small crystals of carbonate of lime and magnesia.

The following is an analysis of the urine of cattle, by Sprengel. One thousand parts contained—

Water	926.24
Solid constituents	73.76
Urea	40.00
Albumen	0.10
Mucus	1.90
Benzoic acid	0.90
Lactic acid	5.16
Carbonic acid	2.50
Potash	6.64
Soda	5.54
Silica	0.36
Alumina	0.04
Oxide of manganese	0.01
Lime	0.65
Magnesia	0.36
Chlorine	2.72
Sulphuric acid	4.05
Phosphorus	0.70

Von Bibra analyzed the urine of oxen employed for agricultural purposes. The urine was of a dark yellow colour, having a peculiar odour. The specific gravity varied from 1032 to 1040.

The following analyses were made with the urine of the same animal, at different times:—

	(1)	(2)
Water	912.01	923.11
Solid constituents	87.99	76.89
Urea	19.76	10.21
Hippuric acid	5.55	12.00
Mucus	0.07	0.06
Alcohol-extract	14.21	10.20
Water-extract	22.48	16.43
Soluble salts	24.42	25.77
Insoluble salts	1.50	2.22

The saline residue contained—

Carbonate of lime	1.07
Carbonate of magnesia	6.93
Carbonate of potash	77.28
Sulphate of potash	13.30
Chloride of sodium	0.30
Silica	0.35
Traces of iron, and loss	0.77
	100.00

The food of the oxen consisted of fresh clover and a little hay. The salts of the saline residue were found to vary very much in quantity in different analyses. As a general rule, the urine of oxen may be said to contain more alkaline and less earthy carbonates than the urine of horses.

Analysis of the urine of a cow fed on after-math and potatoes, by Bous-singault. When treated with an acid it effervesced, and numerous crystals of hippuric acid were deposited. Specific gravity 1040; 1,000 parts contained:—

Water and indeterminate matters	921.32
Urea	18.48
Hippurate of potash	16.51
Lactate of potash	17.16
Bicarbonate of potash	16.12
Carbonate of magnesia, ...	4.74
Carbonate of lime	0.55
Sulphate of potash	3.60
Chloride of sodium	1.52
Silica	traces
Phosphoric acid	absent

The urine of the goat was analyzed by Von Bibra. It was obtained from an animal confined in a stable, and poorly fed upon sour hay, &c. Urine

alkaline, clear, with a pungent peculiar odour. Specific gravity from 1008 to 1009.

In two instances, 1,000 parts contained:—

	(1)	(2)
Water	980.07	983.99
Solid residuo	19.93	16.01
Urea	3.78	0.76
Hippuric acid	1.25	0.88
Alcohol-extract	4.54	4.66
Water-extract	1.00	0.56
Mucus	0.06	0.05
Soluble salts	8.50	8.70
Insoluble salts	0.80	0.40

The ash consisted of:—

Carbonate of magnesia, with a little carbonate of lime . . .	7.3
Sulphate of soda	25.0
Chloride of sodium	14.7
Carbonate of soda with a little carbonate of potash . . .	53.0
	100.0

In the urine of the camel, Chevreul discovered a large quantity of urea, but no uric acid; also chloride of sodium, hippurate of soda, carbonate of soda, sulphate of potash, carbonate of ammonia, a little sulphate of soda, and a trace of peroxide of iron. The phosphates, as well as the urates, were found to be absent.

c. *Urine of the Omnivora*.—Man is the only omnivorous animal whose urine has been carefully examined. We will not unnecessarily repeat analyses which have been performed by distinguished chemists, and are well known. We will only give a few analyses of Lehmann, which may be compared with those of the urine of other animals, and at the same time illustrate several important points, as the influence of diet upon the excretions of the kidney.

Analyses of the urine of a healthy, well-fed, young man, living upon a mixed animal and vegetable diet:—

	(1)	(2)	(3)
Water	937.682	934.002	932.019
Solid residuo	62.318	65.998	67.981
Urea	31.450	32.914	32.909
Uric acid	1.021	1.073	1.098
Lactic acid	1.496	1.551	1.513
Water-extract	0.621	0.591	0.632
Spirit and alcohol-extract	10.059	9.871	10.872
Lactates	1.897	1.066	1.732
Chlorides of sodium and ammonium	3.646	3.602	3.712
Alkaline sulphates	7.314	7.289	7.321
Phosphates of soda	3.765	3.666	3.989
Phosphates of lime and magnesia	1.132	1.187	1.108
Mucus	0.112	0.101	0.110

15.857

15.744

16.130

Under a strictly animal diet, the urine became pale, of a straw-color, limpid, and resembled in appearance and chemical constitution the urine of the carnivora. The following are two analyses of the same man, subsisting upon animal food, made on the 28th and 30th of July, the ninth and eleventh days of the experiment:—

	July 28.	July 30.
Water	909.32	933.27
Solid residue	96.68	66.73
Urea	53.79	41.65
Uric acid	1.41	1.18
Free lactic acid	2.28	1.64
Lactates	1.67	1.02
Extractive matter soluble in water	0.82	0.61
Extractive matter soluble in alcohol	4.50	3.24
Mucus	0.09	0.11
Chlorides of sodium and ammonium	5.37	3.46
Sulphates	11.51	7.08
Phosphate of soda	5.52	4.04
Earthy phosphates	3.72	2.70

Lehmann next investigated the effects of a strictly vegetable diet. The urine had a faint odour, and a decidedly acid reaction. That, passed in the morning, was of a dark-brown colour, and rapidly deposited a mucus sediment; after which, bright-red crystals of uric acid gradually separated.

The following are three analyses which were then instituted, on the ninth, tenth, and twelfth days of the experiment:—

	August 20.	August 21.	August 22.
Water	929.10	941.91	934.92
Solid residue	70.90	58.09	65.08
Urea	23.31	22.42	25.69
Uric acid	1.17	1.01	0.89
Lactic acid	1.55	1.01	1.35
Lactates	2.39	1.89	2.06
Extractive matter soluble in water	3.80	3.07	3.71
Extractive matter soluble in alcohol	17.84	13.78	15.77
Mucus	.12	.10	.10
Chlorides of sodium and ammonium	3.80	3.07	3.71
Sulphates	7.16	7.14	7.23
Phosphates of soda	3.54	3.68	3.74
Earthy phosphates	1.22	1.09	1.11

Analyses of the urine during a strictly non-nitrogenous diet of starch, sugar, gum, and almond oil. The urine, after this diet had been continued for twenty-four hours, became of a brownish-red colour, and a slightly acid reaction, which became alkaline in twenty-four to thirty-six hours.

The following analyses were made on the second and third days from the commencement of this course of diet, in the month of June:—

	(1)	(2)
Water	953.98	965.11
Solid constituents	46.02	34.89
Urea	18.92	11.08
Uric acid	.89	.54
Lactic acid and lactates	4.89	5.11
Extractive matter soluble in water	2.80	2.71
Extractive matter soluble in alcohol	8.32	8.78
Mucus	.11	.11
Chlorides of sodium and ammonium	2.74	1.14
Sulphates	3.25	2.98
Phosphate of soda	3.01	2.48
Earthy phosphates	1.00	.91

The following table gives the mean daily amount of the various solid constituents of the urine, excreted by the kidneys, during these different systems of diet:—

	Mixed diet. <i>Grammes.</i>	Animal diet.	Vegetable diet.	Non-nitrog. diet.
Solid constituents	67.28	87.44	59.24	41.68
Urea	32.50	53.20	22.48	15.41
Uric acid	1.18	1.48	1.02	.73
Lactic acid and lactates	2.72	2.17	2.68	5.82
Extractive matters	10.49	5.20	16.50	11.85

The results of these experiments demonstrate the great influence which diet exerts upon the chemical and physical characters, and the relative amounts of the different constituents of the urine. The amount of solid matters excreted during the twenty-four hours, under a purely animal diet, was more than double that excreted during the same length of time under a non-nitrogenous diet. The amount of urea excreted under the former was more than treble that under the latter. The extractive matters were greatest under a vegetable, and least under an animal diet, while uric acid increased under the latter, and diminished under the former. If the vegetable diet had been persevered in long enough, in all probability, uric acid would have been replaced by hippuric acid, as happened in the case of a girl who fed entirely upon apples.

It is a well-known fact, that, in the urine of herbivorous animals deprived of all vegetable food, hippuric acid is replaced by uric acid. The important principles established by these experiments of Lehmann are confirmed by the differences which exist between the urine of the carnivora and herbivora. In animals living upon animal food, the solid constituents of the urine are in much larger proportion than in that of animals subsisting upon a vegetable diet. The urine of the lion, tiger, and panther contains, in the 1,000 parts, 154 of solid matter. The urine of the bat contains even a larger amount of solids. The urine of hard-working oxen and horses contains not more than from 70 to 100 parts of solid matter, whilst that of the pig contains not more than 20 parts in the same amount.

Lehmann likewise showed by his experiments that, during severe bodily exercise, urica and the lactates, sulphates, and phosphates are increased, whilst uric acid and the extractive matters are diminished.

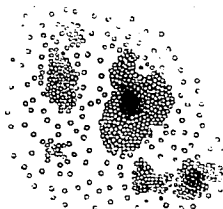
The following are the results obtained from a frequent examination of his urine during a pedestrian tour:—

	In 24 hours. Grammes.	In 1,000 parts.
Water	900.006	916.707
Solid constituents	82.594	83.293
Urea	45.314	45.697
Uric acid	.642	.647
Lactic acid	3.140	3.166
Extractive matters	8.455	8.526
Alkaline phosphates	4.598	4.636
Alkaline sulphates	15.047	15.174
Earthy phosphates	1.105	1.114

2. *Urine of Birds.*—In this class, the urine is characterized by being semi-solid, and consisting, in great measure, of the urate of ammonia, in the form of minute globules, which, when dry, resemble chalk. The following are several analyses which I made last summer.

a. *Carnivorous Birds.*—Qualitative Analysis of the Urine of the Osprey, or Fish-hawk (*Pandion Haliaetus*). The urine of this bird consists of two distinct parts; a white, chalk-like precipitate, and a light yellow, ropy, supernatant fluid, resembling much in its appearance albumen. That it does not contain albumen is proved by the fact that it is coagulated neither by heat nor nitric acid. Under a magnifying power of 210 diameters, the solid white portion consists of innumerable small globules of the urate of ammonia.

Fig. 18.



Appearance presented by the solid white portion of the urine of birds and reptiles, under a magnifying power of 210 diameters. To the naked eye, this resembles chalk; under the microscope, it consists of innumerable minute granules of the urate of ammonia.

Their appearance is represented in Fig. 18. When heated in water, this chalky mass was dissolved, and deposited again upon cooling. When heated to boiling, the ammonia was driven off as a gas, whilst the uric acid was deposited in the form of rhomboidal, lozenge-shaped, and hexagonal crystals. The presence of uric acid was further determined by treating the urine with nitric acid, applying heat, and then testing with aqua ammonia; the production of the characteristic purplish scarlet colour was the result. When treated with acetic or hydrochloric acids, numerous hexagonal, lozenge-shaped, and columnar crystals of uric acid, often conglomerated together in large numbers, were precipitated. When the fluid portion was

treated with aqua ammonia, multitudes of stellate crystals of the triple phosphate were deposited. When the fluid portion of the urine was simply spread upon a glass slide, and allowed slowly to evaporate, there appeared, under the microscope, crystals of the mixed phosphates and fixed alkaline salts, together with crosslets and cubical crystals of the chloride of sodium. We were unable, by a close examination of the urine with the microscope, after it had been treated with nitric acid, to detect any traces of the nitrate of urea.

The following are the principal constituents:—

Urate of ammonia, in large amount.	Phosphate of soda.
Phosphate of lime.	Chloride of sodium.
Phosphate of ammonia.	Purpurine.
Phosphate of magnesia.	No urea.

Qualitative Analysis of the Urine of the Small White Crane (*Ardea Canadissima*).—The amount of urine secreted by this bird in twenty-four hours was three-fourths of a fluidounce. Like that of the *Pandion Haliaetus*, it consisted of a fluid portion, and a white, chalk-like precipitate. Specific gravity of fluid portion 1060. The white precipitate was about one-fourth of the whole amount of the urine. The urine gave a decidedly acid reaction, turning thick litmus blue paper promptly red. The solid portion, like that of the urine of all other birds, consisted of innumerable small globules of the urate of ammonia. When this was rubbed with the hydrated oxide of potassa, powerful fumes of ammonia were evolved, owing to its displacement by a stronger base, the potassa. When the urate of potash, thus formed, was treated with acetic or hydrochloric acids, a copious silvery-white deposit gradually precipitated, which, under the microscope, was found to consist of innumerable crystals of uric acid. The presence of uric acid, in combination with ammonia, was determined by many other characteristic tests. The solid white portion of the urine does not consist wholly of the urate of ammonia. When heated upon platinum foil, it becomes black, and gradually burns away, giving off a disagreeable smell similar to that of burnt feathers, and finally leaves a white residue. Under the continued and more direct action of the blowpipe, a large portion of this fused into semi-transparent, vitrified beads. Portions of the ignited mass were not thus fused, but continued as a white powder, which gave an alkaline reaction with turmeric yellow, and dissolved in acids with effervescence. By various chemical tests, the residue was found to consist of oxalate of lime and phosphates of ammonia, lime, and magnesia. Peniform and stellate crystals of triple phosphate were precipitated from the fluid portion by aqua ammonia. When simply spread upon a glass slide, and allowed slowly to evaporate, prismatic crystals of triple phosphate, cubical crystals, and crosslets of chloride of sodium, and crystals of the other fixed alkaline and earthy salts, were seen under the microscope.

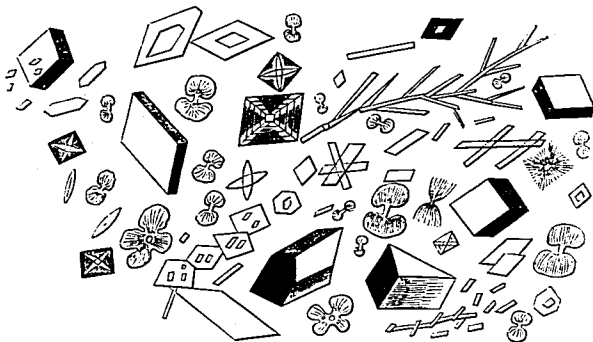
The following are the principal constituents of the urine of this bird:—

Urate of ammonia.
Phosphate of lime.
Phosphate of ammonia.
Phosphate of magnesia.

Phosphate of soda.
Chloride of sodium.
Oxalate of lime.

Qualitative Analysis of the Urine of a young, half-grown Green Heron (*Ardea Virescens*).—The urine of this bird consisted of two portions, and resembled, in all respects, that of other birds. When the transparent liquid portion was spread upon a glass slide, and allowed to evaporate slowly, a magnifying power of 210 diameters revealed numerous dumb-bell and octohedral crystals of the oxalate of lime, lozenge-shaped crystals of uric acid, prismatic crystals of triple phosphate, cubes of the chloride of sodium, and other crystalline forms of the fixed alkaline and earthy salts. The most important and striking of these crystals are represented in Fig. 19.

Fig. 19.



Dumb-bells and octohedra of oxalate of lime, lozenge-shaped crystals of uric acid, cubes and octohedra of chloride of sodium, and prismatic crystals of triple phosphate, deposited in the clear fluid portion of the urine of the green heron (*Ardea Virescens*). Magnified 210 diameters.

The solid, white portion of the urine, like that of the *Ardea Candidissima*, was found, under the blowpipe, to contain other ingredients besides the urate of ammonia.

The following are the principal constituents of the urine of the *Ardea Virescens*:—

Urate of ammonia.
Uric acid.
Urea.
Oxalate of lime.
Chloride of sodium.
Phosphate of soda.

Phosphate of lime.
Phosphate of magnesia.
Phosphate of ammonia.
Fibrinous casts.
Epithelial scales.

Epithelial scales and fibrinous casts were found in considerable numbers in the urine of this young bird. In this examination, we were surprised by the abundance of the crystals of the oxalate of lime.

The presence of oxalic acid in the excretions of the kidneys is always associated with some imperfection of digestion, and often of respiration. Young birds of this class are exceedingly voracious; they will gorge themselves with large and unnecessary quantities of food, and at the same time remain quiet and inactive. Here we have causes amply sufficient to account for the appearance of the oxalate of lime in the urine.

Urine of the Qua-bird, or American Night-heron (*Ardea Discors*).—The urine of this bird had the same appearance, and gave the same chemical reactions, and appeared to be constituted in all respects like that of other cranes.

In examining the urine of birds of this class, we are struck not only with the great amount of the urate of ammonia, but also with the large proportion of the earthy and fixed alkaline salts. Their presence in such abundance may readily be explained by considering the food of the birds, which consists of crabs, fiddlers, sea-conchs, and fish of all kinds, swallowed without any mastication. Although they eject the shells and bones from the stomach through the mouth, after the flesh has been removed by the gastric juice, still it is reasonable to suppose that a considerable amount of the fixed alkaline and earthy salts are dissolved from the shells, by the action of the gastric juice, simultaneously with the digestion of the flesh. The relatively large amount of the chloride of sodium must be derived from the salt water, a portion of which must be swallowed with every crustacean and fish.

The excretion of the kidneys of sea-birds is very abundant, and is the source of that valuable manure, guano. A faint idea of the immense quantities of this substance, deposited by myriads of sea-birds during many centuries, may be formed when we reflect that more than forty thousand tons have been imported to Great Britain and Ireland from the coasts of Peru, Bolivia, Chili, and Africa.

The following is an analysis, by Foureroy and Vauquelin, of a sample of guano presented to them by Baron Von Humboldt:—

100 parts contained—

Urate of ammonia	9.0
Oxalate of ammonia	10.6
Oxalate of lime	7.0
Phosphate of ammonia	6.0
Phosphate of ammonia and magnesia	2.6
Sulphate of potash	5.5
Sulphate of soda	3.3
Sal ammoniac	4.2
Phosphate of lime	14.3
Clay and sand	4.7
Water and organic matters	32.3

The following is an analysis of Bolivian guano, by Andrew Ure:—

The soluble matter = 24 parts in 100, and consisted of—

1. Urea	5.00
2. Sulphate of potash	7.90
3. Chloride of sodium	5.00
4. Biphosphate of ammonia	5.50
5. Oxalate of ammonia	0.60

The insoluble matter = 69.5 parts, and consisted of—

1. Silica	2.25
2. Subphosphate of lime	9.00
3. Phosphate of magnesia and ammonia	1.25
4. Urate of ammonia	15.27
5. Undefined azotized organic matter, affording, with the 14 parts of uric acid, by ignition with hydrate of soda, 17.05 parts of ammonia	41.73

By comparing these analyses with those of the urine of birds, in its fresh state, we see that the urate of ammonia has almost entirely disappeared, whilst the fixed alkaline and earthy salts are relatively in much greater proportions. This is readily explained by the fact that uric acid is readily decomposed into ammonia and carbonic acid gas.

b. Urine of Granivorous and Frugivorous Birds.—In this class, the renal excretion is much less in quantity, and that of the large intestines much greater than that of carnivorous birds. In both classes, however, the urine appears to be similar in physical and chemical properties. The urine of several granivorous and frugivorous birds, I found, by microscopical and chemical examination, to consist chiefly of the urate of ammonia. Vauquelin and Fourcroy found that the urine of the ostrich contained uric acid to the amount of one-sixtieth of its weight. There were present, also, sulphates of potash and lime, chloride of ammonia, and a peculiar oily animal matter. According to J. Davy, the urine of the parrot is very similar to that of serpents.

3. Urine of Reptiles.—The urine of this class resembles that of birds, not only in appearance, but also in chemical constitution, being only a little more solid when first discharged. Here we have the urine of two wholly dissimilar classes alike in all respects. Birds have a high temperature, in many cases 10° higher than that of the mammalia. Their blood circulates with rapidity, and receives an abundant supply of oxygen. Their habits are those of activity.

Reptiles have no definite temperature; it corresponds with that of surrounding bodies. Respiration is imperfect, their lungs being, in most cases, simple sacs, around the walls of which ramify the bloodvessels. Their circulation is sluggish and imperfect, and their habits indolent and inactive.

Would any one suppose, *a priori*, that the secretions of these two classes would be similar? If the explanation given by Liebig be true, that the production of urate of ammonia in serpents is due to their imperfect respiration, and consequent incomplete oxygenation of the blood and tissues, why should

we have the same state of things existing in birds, who have oxygen supplied in large quantities, not only by their lungs, but also throughout the tissues, by means of their porous bones? It is useless to theorize upon this subject in the present state of our knowledge; we must first acquaint ourselves with the chemical constitution of the blood and tissues of cold-blooded animals, before we will be able to attempt an explanation of these apparently contradictory phenomena.

The urine of a land-tortoise (*Testudo Tabulata*), which had been starved for some months, was analyzed by Marchand. It resembled pus in appearance, and had a faintly acid reaction. He collected 1,337 grains, which gave the following analysis:—

		Or in 100 parts.
Water	1271.	950.64
Solid constituents	66.	49.36
Urea	8.5	6.40
Uric acid	23.0	17.25
Hippuric acid	none.	
Salts and indeterminate organic matter	34.5	25.70

The following is a qualitative analysis of the urine of the coachwhip snake (*Psammophis Flagelliformis*), which I made during the month of July:—

When the urine was allowed to stand for a short time, it formed a hard, white mass, which might have been readily mistaken for so much chalk. Under a magnifying power of 210 diameters, it was seen to consist of a conglomeration of innumerable globules of the urate of ammonia, resembling in all respects the solid portion of the urine of birds. Epithelial cells and fibrinous casts of the urinary tubes were also found in considerable numbers.

The following are the results of the microscopical and chemical examination of the urine of this snake:—

Urate of ammonia, in great abundance.
 Phosphate of lime.
 Phosphate of ammonia.
 Phosphate of magnesia.
 Phosphate of soda.
 Chloride of sodium.
 Epithelial cells.
 Fibrinous casts of urinary tubes.

We were unable to detect the presence of urea. I have examined the urine of other snakes, as the pine-snake (*Pituophis Melanoleucus*) and the corn-snake (*Crotalus Guttatus*), and found them to resemble that of the coachwhip in most respects, consisting mainly of the urate of ammonia. We have as yet been unable to detect urea.

In the kidneys of the glossy-black pine-snake (*Pituophis Melanoleucus*), several pyriform calculi were found imbedded in the substance of the kidney, extending from the anterior surface to the ureter. These calculi were found to

consist, in large measure, of the oxalate of lime. Other substances were also present, as urate of ammonia, and the phosphates of lime, ammonia, and magnesia.

The urine of the boa constrictor has been found, by Prout, to yield more than 90. $\frac{1}{2}$ of uric acid. The urine of the rattlesnake has been examined by Simon. The following is his analysis. 100 parts of the dried residue contained:—

Free uric acid, with a little fat and extractive matter	56.4
Urate of ammonia	31.1
Urate of soda, with some chloride of sodium	9.8
Urate of lime	1.4
Phosphate of lime	1.3

This analysis of Simon is calculated to mislead. The urine before analysis was thoroughly dry, all the water having been driven off, and with it much of the ammonia combined with uric acid. In no instance have I detected free uric acid, under the microscope, in the fresh urine of serpents; it exists always in combination with ammonia. The urine of the alligator and lizards consists principally of urate of ammonia. The fixed alkaline and earthy salts exist in considerable quantities in the urine of serpents, especially the salts of lime. Their presence in such abundance may be explained by a consideration of the food and habits of serpents. They are carnivorous, and swallow their prey, often of considerable size, without any mastication. In this manner, a large amount of the earthy salts are taken into the animal economy in the form of scales, bones, claws, teeth, &c. The bones frequently remain in the intestinal canal for a considerable length of time, and they must be acted upon more or less by the gastric juice. In the rectum of a large rattlesnake (*Crotalus Adámanteus*), six feet in length, whose intestinal canal was completely devoid of food, I discovered several balls of hair about two inches in length. When these were opened, they were found to consist of a mass of broken fragments of the bones of an animal, apparently of the size of a rabbit, so carefully wrapped up in the hair that not a single angular point protruded which might injure the intestinal canal. The bones were of a yellow colour, and appeared corroded in many places. The manner in which these bones were in the intestinal canal of the living snake, carefully wrapped up, is unknown.

The urine of the bullfrog (*Rana Taurina*), has been examined by J. Davy. It is a fluid having a specific gravity of 1003, and contains in solution urica, chloride of sodium, and a little phosphate of lime.

The urine of the *Bufo Fuscus* had a specific gravity of 1008, and contained chloride of sodium and phosphate of lime, together with a larger proportion of urea than the urine of the *Rana Taurina*.

4. *Urine of Fish*.—We found it very difficult to obtain specimens of this for examination. The following is a qualitative analysis of the urine of the bassfish (*Corvina Ocellata*):—

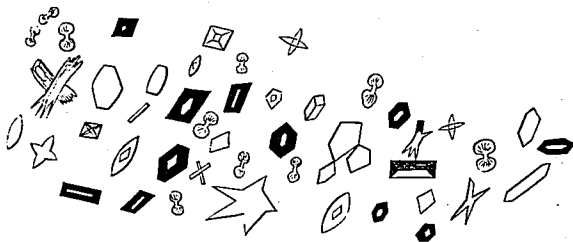
Uric acid.
Oxalate of lime.
Phosphate of lime.
Phosphate of ammonia.

Phosphate of magnesia.
Phosphate of soda.
Chloride of sodium.

When the urine was spread upon a glass slide, and allowed slowly to evaporate under a magnifying power of 210 diameters, there appeared lozenge-shaped and hexagonal crystals of uric acid, dumb-bell, and octohedral crystals of oxalate of lime, and prismatic crystals of triple phosphate.

The appearance presented by the urine thus treated is represented in Fig. 20.

Fig. 20.



Crystals of uric acid, chloride of sodium, phosphate of soda, oxalate of lime, and triple phosphate, which made their appearance under a magnifying power of 210 diameters, in the urine of the bassfish (*Corvina Oxellata*), which was spread upon a glass slide, and allowed slowly to evaporate.

2. Urine of the Invertebrata.

Not much attention, as yet, has been paid to this subject. The following are the results of the investigations of Siebold and others.

The urine of the *Insecta* consists of a fluid containing numerous granular masses, which is poured from the kidneys into the digestive canal, and accumulates in the colon, or in its cœcal appendage, and is excreted with the feces separately or as a turbid liquid, of a colour varying with the species.

The *Lepidoptera*, when bursting from their pupæ, emit a considerable quantity of urine of a variable colour.

In the larva and pupa of *Mymeleon* it is of a rose colour, and gradually accumulates in large quantities in the digestive tube, which the perfect insect immediately discharges on leaving the pupa envelop, as a solid, elongate, ovoid body.

Red crystals, of a quadra-pyramidal form, are perceptible in the urine of many *Insecta*.

The urine of the *Arachnoidæ* is poured by the ureters into the digestive canal, and accumulates in the cloaca, and consists of a turbid, dirty-white liquid, holding in suspension innumerable dark molecules. When treated with nitric acid, heat, and ammonia, it gives the characteristic reactions of uric acid.

In the Crustacea, the urinary secretion has been observed only in the Myriapoda. This, like the urine of insects, contains uric acid.

In the Cephalopoda, the organs, for a long time known as the spongy bodies, have been demonstrated to be kidneys. The urine is secreted from their external surface, and is of a dirty-yellow colour, and escapes immediately into the peritoneal cavities, and thence is discharged externally through their orifices.

Not unfrequently reddish crystals, formed in the urine, completely invest the kidneys, giving to them their peculiar colour.

A chemical analysis of Harless shows that they contain uric acid.

The cells of the kidneys of the Cephalophora contain a transparent liquid, in which float obscure nuclei, of a brown or violet colour. These nuclei are round or embossed, having a dense crystalline structure, and contain uric acid.

The gland of Boganus in the Acephala has been proved to be a kidney; the cells of which generally contain blue-black nuclei, which are sometimes visible to the naked eye as inorganic concretions, and, as they contain uric acid, they may well be compared to renal calculi.

These concretions in the *Petunculus Pilosus* were analyzed by Herrn Von Babo, who found them to consist principally of phosphate of lime, with a trace of magnesian phosphate and a small quantity of uric acid.

Neither kidneys nor their excretions have been, as yet, discovered in the Vermes, Zoophyta, or Protozoa.

ART. II.—*Account of the Asiatic Cholera, as it prevailed in Columbia, Lancaster County, Pa., in the Autumn of 1854.* By T. HEBER JACKSON, M. D. (With a plan of the town.)

It is only by carefully observing and recording the conditions under which epidemic cholera prevails, that we can hope to discover its cause, and the laws by which it is governed. With the hope of contributing some materials for this purpose, we have drawn up the following report:—

It is no easy matter to follow distinctly the progress of an epidemic when it prevails extensively in a large and populous city; but in a small town, its origin and progress can be more readily traced, and we shall endeavour to do this in regard to the disease as it occurred in the town of Columbia, Lancaster County, Pa., during the month of September, 1854.

It will be useful to consider, briefly at least, the situation and aspect of Columbia, and all such conditions as might reasonably be supposed to have exerted an influence upon the development and propagation of the epidemic in that town. To this end, the reporter avails himself of a communication from Dr. A. CLARKSON SMITH, of Columbia.

“Columbia is situated on the north bank of the Susquehanna, forty miles above the Chesapeake Bay, and is the terminus of two canals and three rail-